What would it cost for listed companies to contribute to solving the climate, land and water crises?

The case of the Swiss Market Index

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What would it cost for listed companies to contribute to solving the climate, land and water crises?

The case of the Swiss Market Index

October 25, 2021

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1. Global environmental risks and sustainable finance

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According to the World Economic Forum's *Global Risks Report 2021*, four of the top five most likely global risks[2,3] are related to the ongoing modifications of the environment (mainly climate change and biodiversity loss). Such acknowledgment from the business community resonates with scientific findings from the last decade. According to Rockström et al. (2009) and Steffen et al. (2015), three of the nine global limits that should be respected in order to ensure the survival of humanity have already been crossed. From a country perspective, the current way of producing and consuming in Switzerland and in Europe (Joint EEA/FOEN Report, 2020) is clearly contributing to the global overshoot of these planetary boundaries[4].

It is more relevant than ever to analyze how these global environmental risks will change the current investment and business practices – not only in terms of strategy and costs for companies, but also in terms of financing the transition to a low-carbon economy and halting biodiversity loss for sustainable finance.

We propose here a novel approach, based on Natural Capital Accounting, which highlights the importance of global environmental risks for companies and stock market indices. Beyond current practices, we also evaluate the magnitude of several environmental impacts (climate change, land use and water scarcity) induced globally by the companies of a stock market index and provide an estimate of the net investments (cost of solutions minus avoided costs) needed to contribute to solving these issues.

This approach is applied to the 14 industrial companies included in the Swiss Market Index (SMI), using the latest data published (i.e. for the year 2020) by the companies. The goal is to understand the magnitude of yearly investments required to solve the issues they contribute to, and if these costs are bearable or not. In addition, a comparison with the environmental impacts of Switzerland (those occurring on the territory and those induced by the consumption of the Swiss population) is provided in order to get a better understanding of the importance of Switzerland in terms of global environmental impacts. Finally, lessons learned, and the potential uses of such results by companies and the investment community are discussed.

2. Top 5 risks by order of likelihood: Extreme weather, climate action failure, human environmental damage, infectious diseases, biodiversity loss.

3. The picture in terms of the magnitude of the potential impact is slightly different due to the appearance of COVID: The top 5 risks by order of the size of impact are: Infectious diseases, climate action failure, weapons of mass destruction, biodiversity loss, natural resource crises.

4. See (Dao et al., 2015; Friot and Dao, 2018) for the scientific background reports of this publication.

2. An approach based on Natural Capital Accounting and focusing on the cost of solutions

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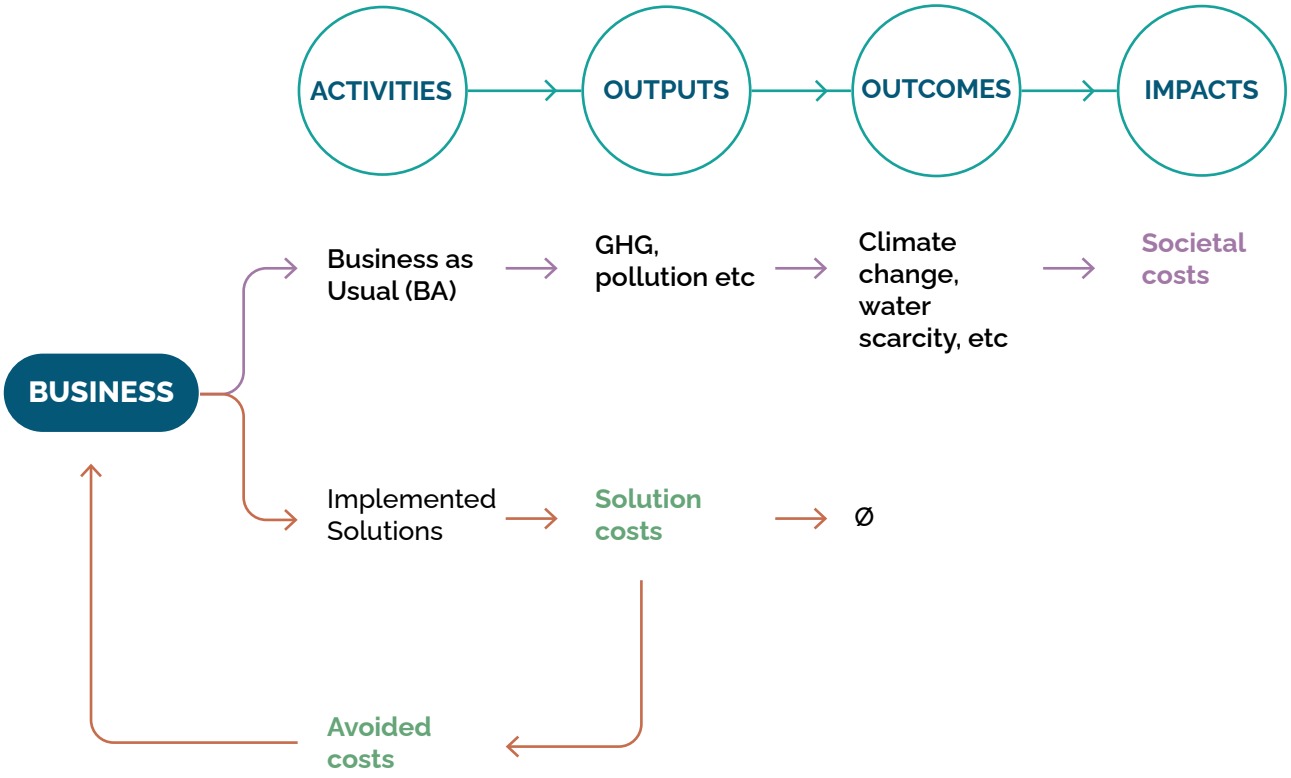
The proposed approach, focusing on the cost of solutions, differs from the classical approach of Natural Capital Accounting, which mostly focuses on the total costs for society (societal costs), as illustrated in Figure 1. While societal costs are useful for evaluating the relative importance of different types of environmental impacts (for example, to understand if climate change is more important than water scarcity, in terms of societal costs), we believe that the cost of a solution is more adequate and relevant for formulating an operational strategy and evaluating the investment needed through an action plan[5].

To get an estimate of the investment needs, two types of costs are considered: the costs of solutions (e.g. solar panels and storage systems) and the costs avoided through the use of these solutions (e.g. cost of fossil fuels avoided due to use of solar panels). The selection of solutions and their combination is subjective and driven by the choices made in our model, as it requires anticipating the future and their possible complex interactions from a technological, financial and societal perspective. The assessment is mostly based on existing cost-curves and regional availability/applicability, prioritizing lower cost solutions first.



The proposed approach (in orange) focuses on the solutions to avoid societal costs resulting from a business as usual (BA) scenario (which involves using fossil fuels as well as non-sustainable management of land and water). The estimation of costs is thus more realistic of the required spending to solve an issue than traditional approaches of Natural Capital Accounting (in purple) focusing on societal costs (i.e. the sum of the costs that a society has to cope with because of an environmental issue).

Figure 1 – Comparison of the proposed and the traditional approach of Natural Capital Accounting.

5. See the scientific background report by (Friot et al., 2018), for a more detailed explanations of the differences between the two approaches.

The evaluation is based on a mix of reported information and modeled estimates due to the limited availability and coverage of full operations and supply chain details in published company data. A four-step approach has been applied to estimate the solutions costs from financial and environmental information reported by companies (see appendix A for more details):

1) Financial information publicly reported by the analyzed companies is first harmonized[6] to serve as the input for a detailed economic-energy-environment model of the world economy.

2) The environmental impacts of each company are computed with the model, considering average supply chains worldwide. These model-based estimates are used in two ways: a) to mitigate the lack of reported data for water scarcity and land use, and b) to provide additional details on the sources of the impacts, e.g. the type of fuel for heating. For greenhouse gas (GHG) emissions, data reported to the CDP is preferred over the results of the model, whenever possible (i.e. when data relevant to the considered scope is reported – which was the case for 11 of the 14 companies).

3) The reduction potential and costs (annualized costs considering capital expenditures, including operations and maintenance costs) of more than 100 solutions, addressing four[7] of the most important global environmental issues (climate change, water scarcity, land use, and transformation and biodiversity losses), are evaluated per economic sector and country worldwide. The magnitude of the required changes is driven by the environmental needs and the potential in each region.

4) The solutions are applied per company, according to the localization of their impacts, considering direct activities and activities in their supply chain. This allows for the computation of the reduction potential per company and per country (considering the additional impacts of the solutions) and the investment needed.

6. Reported data on income (and purchasing) per region and data per product segment are reconciled to have a coherent global vision of the distribution of income (and purchasing) among product segments in each region.

7. To avoid double counting, two categories of solutions are effectively modeled: solutions for climate change and for water scarcity. Land use and transformation, as well as biodiversity losses are thus covered implicitly. IPBES drivers such as pollution, natural resources use and exploitation, and invasive species are thus not included. See more information on IPBES: https://ipbes.net/models-drivers-biodiversity-ecosystem-change .

3. Swiss Market Index: Environmental impacts and costs of solutions

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The evaluation focuses on the 14 industrial companies included in the Swiss Market Index (SMI) as of 30th June 2021. The six financial and insurance companies in the SMI have been excluded from this evaluation since the impacts of their investments and loans should be considered rather than the impacts of their supply chain[8].

We estimate that the activities of the evaluated non-financial companies generated about 305 million tonnes of greenhouse gas emissions (GHGs, measured in CO_2-equivalent) collectively in 2020, accounting for direct operations and supply chains worldwide. As shown in Figure 2, this is equivalent to around 6.5 times the emissions in Switzerland[9] (which was 46.2 million tonnes of CO_2-equivalent in 2020) and 2.5 times the total emissions induced worldwide by the Swiss citizens, taking into account the emissions induced by their consumption (Federal Statistical Office, 2018). This amount is similar to the territorial fossil emissions of France[10]. Water use is also comparatively more than that in Switzerland (close to 12,000 million m^3, i.e. 3.5 times larger). The cropland area used by these companies amounts to about 6.5 million ha globally, more than 1.6 times the area of Switzerland.

When viewed from a Swiss perspective, the magnitude of the environmental impacts of the largest listed Swiss-based companies is significant (even without considering financial and insurance companies). The role played by Switzerland in the generation of environmental impacts worldwide, is thus larger than what is usually expected from existing assessments (based on territorial emissions or emissions from a consumption perspective). The same is true for the potential role of the Swiss society in the reduction of worldwide impacts.

Figure 2 - GHG emissions in Switzerland, induced worldwide by consumption in Switzerland and induced worldwide by Swiss based companies.

8. Evaluating investments and loan books would require additional methodological developments before a potential estimation: considering funds of funds and derivatives would, for example, require many assumptions due to the lack of easily available public information on their composition.

9. The territorial emissions considered in the Paris Agreement.

10. 315 million tonnes of CO_2-equivalent in 2019 (European Commission. Joint Research Centre, 2020).

Considering the nine groups of solutions[11] included in the assessment, yearly investment costs of CHF 21.5 billion would enable a reduction of 29% of the GHG emissions for the considered companies[12]. This reduction potential is quite low, as the direct emissions from the largest emitter of the index (Holcim) are industrial emissions, for which no solutions have been considered in the study, due to the lack of solutions currently deployable at scale. These yearly investment costs would, however, also enable the sustainable management of water (eliminating water depletion and impact on ecosystems), as well as a reduction of land use impacts to a sustainable level (including avoiding deforestation and changing land use practices to preserve soils).

In order to contribute to the global carbon neutrality, additional investments are needed to address the remaining GHG emissions. Offsetting[13] is the first option which can be considered, although it may be termed as outdated, since it is not sufficient anymore to tackle climate change. At the current average global cost per tonne of carbon on the voluntary carbon market (i.e., using a high estimate of CHF 6 per tonne of CO_2-equivalent), an additional yearly investment of CHF 1.3 billion would be needed. A second option, which would enable those companies to contribute to the global carbon neutrality (global net zero), is complementing the identified solutions with projects adding carbon sinks. This option would comparatively cost an additional CHF 6.5 billion annually, assuming a cost of CHF 30 per tonne[14]. It is important to emphasize that offsetting and carbon sinks are only considered to be valid options for the remaining emissions after application of reduction actions by companies, given their limitation to sufficiently tackle climate change at a global scale. The priorities for action are: 1) reducing emissions in Scope 1 (own direct emissions) & in Scope 2 (bought electricity and heat), followed by 2) reducing emissions in Scope 3 (called "insetting"), before 3) adding carbon sinks (removal projects) and, 4) offsetting (compensation).

Total yearly investment costs, including the costs of solutions and contributions to global carbon neutrality, can thus be estimated to be close to CHF 28 billion for contributing to solving the climate, land and water crises by the considered companies[15]. This corresponds to approximately 60% (46% for the solutions and 14% for the contribution to carbon sinks) of the annual profit (net income) of these companies and is equivalent to 4% of the GDP of Switzerland in 2020. The required investment is lower than the yearly societal costs induced by the environmental impacts of their activities, valued at CHF 44.1 billion considering the usual average costs of such externalities[16].

11. The nine groups of solutions considered: renewable electricity, sustainable transportation, sustainable heating, sustainable refrigeration/AC, sustainable agriculture, reducing deforestation, agricultural water management, industrial water management, and water supply solutions.

12. This amount considers investments in the operations and in the supply chains of those companies. Achieving a larger reduction of GHG emissions would require considering solutions for the sources of emissions not considered explicitly here (e.g. industrial emissions).

13. Offsetting basically means investing to reduce the emissions of someone else in the future (e.g. by developing clean energy technologies). Contributing to the global carbon neutrality (global net zero emissions) means adding additional carbon sinks to capture the remaining emissions. Carbon sinks can be developed with natural approaches (e.g. forest restoration) or technological ones (e.g. carbon capture and storage).

14. The price of the first certificate for carbon removal sold: www.puro.earth .

15. Investments are annualized to consider a wide range of solutions with different characteristics. Investments in renewable electricity, for example, will enable several decades of production while new natural carbon sinks will be added yearly to capture residual emissions. These annualized investments consider capital expenditures, operations, and maintenance costs. They are not an investment plan but represent the annual cost of the solutions from a medium-term perspective.

16. Usual average societal costs: CHF 100 per tonne of CO_2-equivalent for climate change, CHF 0.5 per m3 of water for water use, and CHF 1200 per hectare for land use.

It should be noted, however, that the direct comparison of the companies' profit with investment needs is misleading, as most of the solutions will be implemented in their supply chain, i.e., by other companies or stakeholders (and in other countries). The cost will be shared among the different stakeholders of a supply chain, according to their bargaining power, for instance.

The total yearly net investment costs could, however, be much lower than CHF 28 billion since the deployment of solutions will be accompanied by potential direct cost savings. They are estimated at approximately CHF 34 billion annually, indicating the possibility of net savings. These avoided costs would also be distributed among different stakeholders and are not closely related to the direct operations of the companies in the SMI.

3.1 Cost of solutions per environmental impact

The breakdown of environmental impacts, solutions costs (annualized costs considering capital expenditures and operations and maintenance costs) and avoided costs (annual costs resulting from buying less resources) is presented in Table 1.

Overall, for the analyzed companies, most of the costs are induced by solutions targeting climate change. These costs are 13 times higher than the costs for achieving a sustainable water use. In terms of potential savings, most of the avoided costs would also originate from solutions to mitigate climate change. The potential economy per unit of money invested is, on average, larger for water solutions (net unit cost of CHF 8 vs CHF 0.5 for climate change solutions).

It is important to understand that most of the considered solutions have additional co-benefits for other environmental issues, for example, in terms of the reduction in biodiversity losses, which are not explicitly accounted for in the study. The solutions targeting climate change may also result in water-related benefits, which are not accounted either.

	Environmental Impacts	Solution costs (Million CHF/year)	Avoided costs (Million CHF/year)	Solution costs to net income (%)
Climate change	305 M tonnes CO2-equivalent	19,967 (+ 6,478 for the contribution to carbon sinks)	34,039	43% + (14% for the contribution to carbon sinks)
Land and biodiversity	6.5 Mha	*Considered into the costs of climate change and water use*		
Water use	11,825 Mm^3	1,532	106	3.3%

Table 1 – Summary of yearly environmental impacts, solution costs, costs for the contribution to carbon sinks along with avoided costs for the companies of the SMI index (M is for million).

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3.2 Cost of solutions per solution group and value chain perspective

A breakdown of solutions costs per solution group and per position (scope) in the value chain is presented in Figure 3, including their contributions to carbon sinks.

Considering solutions costs only (i.e., without considering contributions to carbon sinks), sustainable transportation (covering emissions from the transportation sector and emissions from the vehicles owned by companies) and sustainable heating require the largest investments (67% collectively). Adding the solutions for renewable electricity covers 93% of the investment needs. This is in line with current knowledge on emissions sources (these three activities are responsible for close to 60% of the emissions according to Clarke and Jiang, 2014. Reducing deforestation or boosting sustainable agriculture seem significantly less expensive to implement (less than 1% of the needed investments), even with one of the world's largest food companies (Nestlé) as part of the SMI.

In terms of total investment costs, the costs of financing projects for adding carbon sinks to tackle the remaining GHG emissions amounts to about 23% of these costs.

Unsurprisingly, from a value chain perspective, most of the solution costs occur in the supply chain[17] of the considered companies, with about 2% of the solution costs directed to address electricity, steam and heat production by direct suppliers (Scope 2) and 73% to address the rest of the upstream supply chain (upstream Scope 3). The additional costs of solutions (25%) are induced by direct operations (i.e., the operations controlled directly by the companies, also called Scope 1 in GHG accounting[18]).

The total investments costs *directly* in the control of the analyzed companies (i.e., in their Scope 1) are estimated at about CHF 3.7 billion per year for the solutions, totaling to about CHF 7 billion when including contributions to global net zero emissions. As mentioned earlier, the additional costs in the supply chains would be shared among multiple stakeholders, including the public sector.

17. Most of the environmental impacts are usually occurring in the supply chain of companies except in the rare cases of integrated structures or in companies using a lot of energy, e.g. for cement manufacturing.

18. The most applied standard worldwide is the GHG protocol: https://ghgprotocol.org .

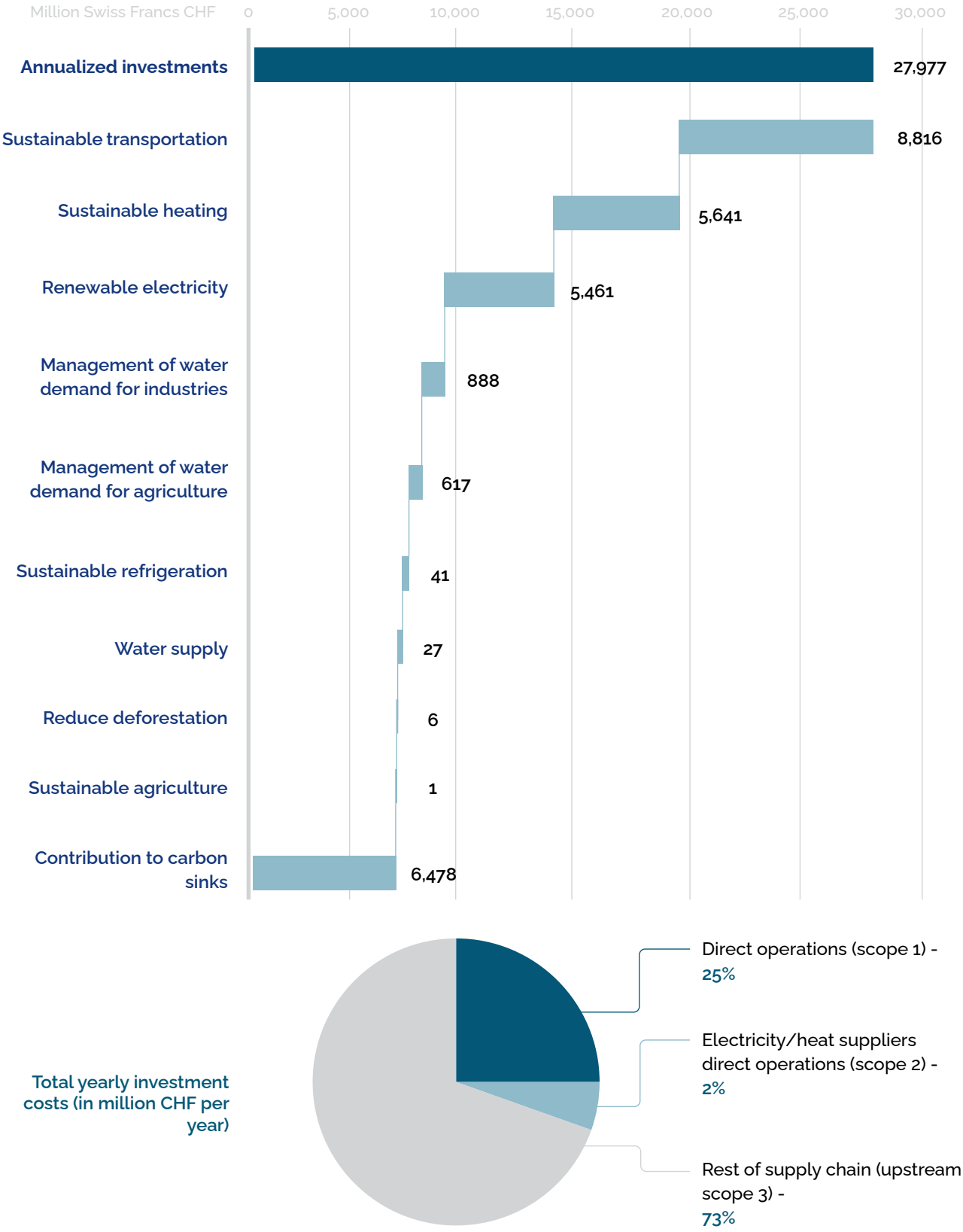

Figure 3 - Annualized investment costs per solution group and carbon sinks costs (above) and value chain perspective (below). (Million Swiss Francs CHF).

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A breakdown of the solutions costs and the avoided costs is presented in Table 2 for climate change and land use solutions, and in Table 3 for water scarcity and land use solutions.

Climate change and land use

Investments in six solution groups are considered – sustainable transportation (41% of the solution costs for climate change, without considering contributions to carbon sinks), sustainable heating (26%), renewable electricity (25%), sustainable agriculture (<1%), reducing deforestation (<1%) and sustainable refrigeration/air conditioning (AC) (< 1%).

The solutions for sustainable transportation and sustainable heating are based on the strong assumption that all fossil fuels could be replaced by renewable electricity (as opposed to substituting fossil fuels by renewable fuels). The magnitude of the avoided costs is due to the price differential between the two alternatives and is subject to change in the future based on market trends. Renewable electricity is modeled in the relevant (renewable electricity) solution group, using the 2050 electricity mix per region as estimated by the International Renewable Energy Agency (IRENA, 2018). The other solutions groups are detailed in Appendix A.

Offsetting and contribution to carbon sinks cover the emissions that are not addressed through the selected solutions. These costs are low despite the size of the GHG emissions involved (two third of the emissions with half due to the direct emissions from Holcim) since they are based on the (low) average prices of these markets. It is important to re-emphasize that these options cannot be considered as first rank solutions and are only valid for addressing the emissions remaining after reduction actions have been taken by companies.

1. Climate change and land use

Solution costs (million USD/year)

Solution group	Total	Direct operations	Electricity/heat suppliers - direct operations	Supply chain
Sustainable transportation	8,816	1,090	0	7,726
Sustainable heating	5,641	1,114	0	4,527
Renewable electricity	5,461	1,259	232	3,970
Sustainable refrigeration/AC	41	6	0	35
Reducing deforestation	6	0	0	6
Sustainable agriculture	1	0	0	1
Contribution to carbon sinks	6,478	3,348	0	3,130
Total	**26,445**	**6,818**	**232**	**19,395**

Avoided costs* (million USD/year)

Solution group	Total	Direct operations	Electricity/heat suppliers - direct operations	Supply chain
Sustainable transportation	17,685	2,194	0	15,491
Sustainable heating	11,328	2,242	0	9,086
Renewable electricity	4,881	1,115	213	3,553
Sustainable agriculture	39	0	0	39
Total	**33,933**	**5,550**	**213**	**28,170**

Table 2 – Climate change and land use: solutions costs, carbon sinks costs, as well as avoided costs for the considered companies of the SMI.

Water scarcity and land use

Two types of solutions are considered for water scarcity issues. First, demand-driven solutions (agricultural and industrial water demand management) based on optimization of water use are given higher consideration in the evaluation, followed by supply-side solutions to tackle the remaining water gap (i.e., the provision of an additional supply of water). The first type of solutions would require 7% of the total solution costs without considering contributions to carbon sinks, while the second type would require less than 1%. While most of these costs (58%) would be for industrial water management, this proportion would vary based on countries.

2. Water and land use

Solution costs (million USD/year)

Solution group	Total	Direct operations	Electricity/heat suppliers - direct operations	Supply chain
Industrial water demand management	888	197	383	308
Agricultural water demand management	617	0	0	617
Water supply solutions	27	1	3	22
Total	**1,532**	**198**	**386**	**948**

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Avoided costs* (million USD/year)

Solution group	Total	Direct operations	Electricity/heat suppliers - direct operations	Supply chain
Industrial water demand management	10	2	4	4
Agricultural water demand management	94	0	0	94
Water supply solutions	2	0	0	2
Total	**106**	**2**	**4**	**100**

** Avoided costs are only partially considered.*

*** Only a part of water use should be reduced to be in accordance with the planetary boundaries, the so called "water gap".*

Table 3 – Water scarcity and land use: solutions costs, compensations costs and avoided costs for the companies of the SMI.

3.3 Cost of solutions per company of the SMI

The total investment costs estimated per company are set in perspective of their revenue and environmental impacts in Table 4. In terms of revenues, the three largest companies of the SMI index (with more than 60% of revenues) are Nestlé (28% of the revenues), Roche (19% of the revenues) and Novartis (15% of the revenues). These three companies also induce the largest impacts in terms of land and water, with Nestlé (76% and 56% respectively) being the predominant contributor. The situation is however different for climate change for which Holcim is the largest emitter (45% of the emissions of the SMI index), followed by Nestlé (37% of the emissions) and Novartis (2.8%).

The total investment needed (considering investments in carbon sinks) is largest for Nestlé (49.3%), followed by Holcim (25.3%), and Roche (5.2%). The investment estimated for Holcim is in the lower range since a majority of their investments would be in carbon sinks (88% of their emissions) which are of comparatively lower cost. The costs will likely be higher once solutions are available and deployed at scale.

The total annual investment needs for Nestlé are estimated at CHF 13.8 billion, with about CHF 11.6 billion directed towards the solutions. This value can be compared to the investments suggested in the net zero strategy of Nestlé[19] (CHF 3.2 billion by 2025 in total to reduce emissions

19. Source: Nestlé Net Zero Roadmap. February 2021 (https://www.nestle.com/sites/default/files/2020-12/nestle-net-zero-road-map-en.pdf).

by 20%). A relevant comparison of the two values is difficult due to the lack of information on the costs for 80% of the emissions, and with repeated costs over time.

This ranking of companies in terms of solution costs is influenced by three factors. First, the characteristics of each company – the magnitude of sales and their distribution among activity segments and countries, as well as the geographical distribution of the supply chains. Second, the share of the GHG emissions which is considered explicitly with solutions in the model. The fuels burned by Holcim for producing cement are, for example, not considered in terms of solution but in terms of carbon sinks since there is currently not a widespread and evident solution to substitute them (although some alternatives are emerging). This results in a lower cost for considered solutions despite the high emissions. Third, the difficulty to model some of the companies with a global economic-energy-environment model due to the model specificities (e.g. in terms of sectoral decomposition). Pharmaceutical companies are, for example, difficult to model adequately.

Revenue (%)	Climate change (%)	Land (%)	Water (%)	Total investment costs (%)
Nestlé (28.0%)	Holcim (47.7%)	Nestlé (76.3%)	Nestlé (56.0%)	Nestlé (49.2%)
Roche (19.4%)	Nestlé (38.5%)	Novartis (7.94%)	Novartis (10.7%)	Holcim (25.3%)
Novartis (15.1%)	Novartis (2.8%)	Roche (4.78%)	Roche (9.74%)	Roche (5.2%)
ABB (8.2%)	Roche (2.7%)	Holcim (3.26%)	Holcim (8.3%)	Novartis (4.8%)
Holcim (7.7%)	ABB (2.3%)	Richemont (2.10%)	Richemont (3.4%)	ABB (3.7%)
Richemont (4.7%)	Sika (1.2%)	Givaudan (1.87%)	ABB (3.4%)	Swatch (2.6%)
Swisscom (3.7%)	Swatch (1.1%)	ABB (1.42%)	Givaudan (2.8%)	Alcon (2.4%)
Sika (2.6%)	Lonza (0.8%)	Sika (0.57%)	Sika (2.1%)	Lonza (1.9%)
Alcon (2.1%)	Givaudan (0.8%)	Swatch (0.49%)	Lonza (1.2%)	Sika (1.5%)
Givaudan (2.1%)	Alcon (0.7%)	Lonza (0.44%)	Swatch (1%)	Givaudan (1.1%)
SGS (1.9%)	Richemont (0.5%)	Alcon (0.34%)	Alcon (0.6%)	SGS (0.7%)
Swatch (1.9%)	SGS (0.4%)	SGS (0.14%)	Geberit (0.3%)	Geberit (0.7%)
Lonza (1.5%)	Geberit (0.3%)	Swisscom (0.12%)	SGS (0.2%)	Richemont (0.7%)
Geberit (1%)	Swisscom (0.1%)	Geberit (0.07%)	Swisscom (0.2%)	Swisscom (0.3%)

Table 4 – Decomposition of revenues, contribution to impacts and solutions costs per company of the SMI.

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4. Interest and limitations of the approach

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For a stock market index and its constituents, the proposed approach and results enable the understanding of the scale of the environmental impacts induced worldwide as well as the investments required to solve these issues per group of solutions, considering both solution costs and avoided costs. The considered solutions only provide an approximation of the solutions that could effectively be deployed in the value chain of companies. The modeled value chains reflect market averages rather than the company-specific value chains and have been generated using publicly-available information only.

This report brings three important additions to current knowledge:

- A focus on the solutions for solving the current environmental crises rather than focusing mainly on the assessment of the problem as it is usually the case.

- A different perspective in the field of Natural Capital Accounting with a focus on the required investments (costs of solutions and avoided costs) to solve the main environmental risks from a private sector perspective (internal cost), rather than the classical focus on the cost to society (externality).

- An evaluation of the environmental impacts induced by the large industrial companies of Switzerland, in terms of climate change and water. This evaluation complements the known evaluations of the environmental impacts of Switzerland from a territorial perspective (i.e., impacts in Switzerland) and from a consumer perspective (i.e., impacts induced globally in the world by the consumption of Swiss citizens).

The effort to generate such results is considerable, especially due to the large amount of data required to generate relevant information for action. Over the last four years, several iterations of this model have been generated to increase the robustness of the results through the addition of solutions and more spatialization. In terms of impacts, changes of the model over time have allowed a finer analysis, although the order of magnitude of the results has not significantly changed. While a much larger range of environmental impacts could be computed with the generated model (non-renewable energy use, marine eutrophication, freshwater eutrophication as well as air pollution and human toxicity), they have not been included in this report as they are not needed for a first estimation of the scale of the needed investments (they are tackled by the same set of solutions and thus, the costs are the same). Including specific solutions for additional aspects like water quality and biodiversity would, of course, be of interest.

These results correspond to the best possible estimate of the environmental impacts and costs of the industrial companies included in the SMI index, considering current knowledge and the fact that this analysis draws only from publicly available financial and environmental data. The directionally correct results can be used to raise awareness and support strategic discussions, as well as planning investment to finance current solutions to mitigate climate change, water scarcity and the global land crisis.

Further, additional or different solutions, which were not included in this evaluation, should also be considered. Innovation in this field is rapid but requires important investments to be effective and profitable at large scale. Many of them require further developments before their possible inclusion. For many of the existing solutions not considered here, the costs of solution and

possible deployment size are difficult to find. For example, for land use, a robust list of solutions along with their regionalized costs still needs to be developed. In addition, sector-specific solutions could be included to better reflect economic activities having a large environmental impact. This is (for example) the case for Holcim, for which fuel burning for cement production is not considered explicitly, since alternatives with potential to be deployed at large scale, are still in the pilot stages. The same is true (for example) for Nestlé, where specific activities related to cocoa, coffee, palm oil and other key commodities cannot be modeled specifically given the lack of available public data that could be easily included in the model. Additionally, for some activities, a change of business model will be the best solution, an aspect not considered in this report.

Further, while this report uses absolute targets for evaluating the needed impacts reductions, whenever possible, to be in line with the spirit of Science Based Target Network and the Planetary Boundaries framework (i.e., a sustainable water management system so as not to endanger the ecosystems, or net zero carbon emissions), other reduction targets can be used, resulting in potentially widely different results. For example, the Joint EEA/FOEN Report (2020) can be used for a review of possible ways to set targets according to the various principles or publications from the Science Based Target Network[20].

In order to improve the quality of the generated results, it would be interesting to a) collect primary data from the assessed companies, through desk research and direct questionnaires sent to companies, in order to reduce the data gap, b) develop a more exhaustive, local list of solutions along with associated costs per sector and country, and c) to use a more recent, detailed model of the world economy to improve the quantification of environmental impacts.

The main limitations of this study are the lack of a) relevant and reliable published data by companies on Scope 3 environmental impacts, and b) transparent information on the segmentation (sales by activity and by country) of their financial results, making large assumptions unavoidable.

20. https://sciencebasedtargets.org/ .

5. Looking forward

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This report, while acknowledging current limitations, shows that it is possible to use the limited available public data to evaluate the magnitude of costs required to tackle the climate, land and water crises by the listed companies. It also highlights the importance of contribution by companies of the SMI Index to the global environmental emergency from a Swiss perspective. While the first goal is to keep a planet adapted to human life, the report shows that there is an economic rationale to invest in solutions now to lower these environmental impacts. These are not unbearable costs, especially if shared across companies, the public sector and other organizations, including the financial sector. Further, early adoption of the solutions will lead to additional gains for Switzerland in terms of technology, business position and image.

The report will also help in raising awareness towards finding solutions to tackle the climate, water and land crises, and drive focus on reallocating capital to create a sustainable future for our society. This would be a major mindset shift from current practices, which focus mainly on the assessment of the problem rather than that of the solutions.

The order of magnitude of the provided results can be used as the basis for future discussions between these companies and their stakeholders. From an investment perspective, the use of such results can serve not only for stakeholders' engagement, but also potentially for exercising voting rights at shareholder meetings, supporting thematic investments, identifying exclusion criteria for investments, identifying best-in-class companies for creating a sustainable index, and risk assessment and valuation as solution costs might be internalized at some point in the future.

Further, these results and model may be applied within companies themselves, as a starting point, with the inclusion of additional primary data to get more precise results. The same approach could be applied to other companies and stock market indices as well, and to various regions and countries.

5.1 Recommendations for companies

The private sector and multinational companies are key actors in the mitigation of environmental impacts. Considering the growing political and civil society pressure, companies are likely to risk their social license to operate, if they fail to adequately address the impacts of their activities. Significant physical and transitional risks to companies and their shareholders due to climate change is gradually being recognized. The risks are mainly additional costs and loss of market position. The need of investing in the right solutions and engaging with suppliers, or even adapting business models has become apparent. Companies should therefore consider:

1) Increasing transparency and aiming for exhaustive reporting on their activities and environmental impacts in a standardized way[21]. Such information is key for shareholders who would like to seriously evaluate the efforts that companies are making toward sustainable management and business models. It is also key for investors looking to

21. Current developments are, for example, the EC guidelines on non-financial reporting: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019XC0620(01), or Integrated Reporting (e.g. www.integratedreporting.org).

integrate sustainability in investment decisions and engage in a constructive dialogue with their investee companies, to push them towards reducing their environmental impacts.

2) Quantifying and analyzing the materiality of their direct and indirect environmental impacts and reviewing the adequacy of portfolios against solution costs.

3) Identifying and assessing the available solutions and estimating the required investments in direct operations.

4) Financing and implementing solutions in direct operations to reduce their environmental impacts.

5) Engaging in dialogue with their suppliers and support them in their reduction efforts.

6) Collaborating with other companies active in the same industry to promote best practices and solutions both in direct operations and within supply chains, and potentially share development costs.

5.2 Recommendations for investors

5.2.1 Investment decisions

Investors can integrate advanced Natural Capital Accounting models such as the one presented here to:

A) Identify environmental risks and opportunities within their portfolio. Several tools are available for assessing the impact of a portfolio. For example, on biodiversity, see the Global Biodiversity Score (GBS) by CDC Biodiversité (not tested by the authors).

B) Avoid companies that have the highest solutions costs, if they are not internalized, or for which solutions cannot mitigate their impact with reasonable investments.

C) Prioritize companies that are already investing in solutions and will benefit from the resulting avoided costs.

D) Identify companies that are proposing such solutions and can benefit from the transition.

E) Report the global and regional environmental footprints of their portfolio and the required investments to mitigate its environmental impacts.

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5.2.2 Engagement activities

Measuring the environmental impacts of investee companies and evaluating the investments required to mitigate these impacts can become an integrated part of the investor's engagement process by:

1) Requesting better transparency on the environmental impacts of companies, especially in their supply chain.

2) Requiring the board of directors to deal with environmental issues and asking companies to have an environmental- and biodiversity-related policy (for example, deforestation policy and commodity-specific policies like on soy, beef or wood pulp).

3) Making companies aware of their impacts and of the existing solutions and investment needs.

4) Discussing with companies the best strategies to mitigate their impacts (investments into solutions or divestment of business for which solutions cannot be deployed).

5) Requesting further CAPEX on these long-term solutions to mitigate impacts (including Scope 3).

6) Integrating required investments by companies into the voting activities of investors, to mitigate their impacts.

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5.3 Recommendations for governments and lawmakers

Governments and lawmakers play a crucial role in incentivizing companies and investors to fully integrate environmental impacts and dependencies into their business plans and investment decisions. As such, governments and lawmakers are encouraged to:

1) Create incentive for companies to make solutions available and attractive by eventually subsidizing the most efficient solutions.

2) Create mandatory reporting requirements for companies and investors allowing an adequate measurement of the environmental impacts, including upstream and downstream impacts (Scope 3)[22].

3) Consider a new type of environmental assessment, like a "Country-based companies' footprint" complementing the currently applied territorial and consumption perspectives in order to understand the global impacts of companies having headquarters in a country.

4) Promote a Taskforce on Nature-related Financial Disclosure (TNFD) at a high level. The Government and financial regulators will be requested to provide an official mandate to the TNFD through virtual and in-person workshops, during both dedicated and global events.

22. See the recommendations of the EU Task Force on Climate-related Financial Disclosures (TCFD) and of the Disclosure Regulation (SFDR).

6. References

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7. Appendix A: Methodology

Friot D., Vionnet S., What would it cost for listed companies to contribute to solving the climate, land and water crises? The case of the Swiss Market Index. October 25, 2021.

7.1 Scientific background report

This publication is based on the scientific background report by Friot et al. (2018). This report provides additional explanations on the rationale of the approach, additional indicators and costs, as well as a preliminary case study on Nestlé. The methodology applied here is an improved version of this approach, bettering mainly but not only, the two main limitations of the model – considering a larger number of solutions and applying regionalized solutions costs from accepted sources.

7.2 Description of the approach

As explained in Chapter 2, a four-step approach has been applied to go from financial and environmental information reported by companies to potential solutions costs[23].

In a first step, financial information reported publicly by the companies is harmonized to serve as input to a detailed economic-energy-environment model of the world economy. This is a necessary step as a coherent perspective is usually not provided in the reporting. For each company, reported data on income (and purchasing) per region and per product segment are aligned to have a coherent global vision of the distribution of income (and purchasing) among product segments in each region.

In a second step, the harmonized company data is fed into the world economic-energy-environment model[24] to compute all the economic activities generated per company in the 49 countries/regions that constitute the world, in over 200 sectors, and their induced environmental loads. Economic activities and environmental impacts are split into three categories – Scope 1 (direct impacts of a company), Scope 2 (impacts from bought electricity and heat) and upstream Scope 3 (upstream impacts within the economy). Downstream emissions of Scope 3, like the impacts generated while using a product sold by a company, are not considered. Scope 1 and Scope 2 activities and impacts are computed using income data while Scope 3 activities and impacts are computed using purchasing data.

A bridge is established between corporate data and the world economic-energy-environment model by matching a relevant sector of the model per product segment and a relevant region of the model per region of activity. Four scenarios are run for each product segment and averaged to reduce the uncertainty of matching a segment with a wrong sector. When corporate information is only available for a large region, for example, Europe, data is further split between the countries

23. A 1 USD/CHF exchange rate is considered in this report.

24. The world economic-energy-environment model is based on Exiobase (Stadler et al., 2018), a global Input-Output model of the MRIO type for the year 2011. It is extended with additional data to enable computing detailed environmental impacts and solution costs.

of the region according to production values per sector in each country. The result is a detailed model of a company income and purchasing split among 49 regions covering the whole world and with as many sectors as there are product segments.

Additionally, available good quality corporate environmental information is considered to replace modeled data. Currently, we estimate this is only the case for GHG emissions reported to the CDP (and only when categories considered are relevant, as qualified by the companies themselves in the CDP, are all provided). These values are used to scale the part of the data generated with the model corresponding to the emissions considered in the CDP (i.e., all fossil fuels related GHG emissions). The advantage of this approach is to keep the detailed breakdown of emissions and costs per group of solution from the model while matching corporate expectations in terms of total and Scope-wise distribution. This is needed because multinational corporations often have an economic structure (level of vertical integration) and emissions intensity (because of energy and environmental management) which differ from the sector averages as available in the global model. For the companies which are not (or incompletely) reporting GHG emissions to the CDP, as well as other environmental aspects lacking good quality public information, the results of the model are taken as such. In the case of the SMI, the CDP Scope 1, 2 and 3 totals are thus considered for ten companies, with Scope 1 and 2 considered for one company (Lonza) and the results of the model for three companies (Alcon, Sika and Swatch).

In the third step, the reduction potential and costs (annualized costs considering capital expenditures as well as operations and maintenance costs) of more than 100 solutions addressing four[25] of the most important global environmental issues (climate change, water scarcity, land use and transformation and biodiversity losses) are evaluated per economic sector and region of the world. Both current environmental impacts and the reduction potential in each region are considered (solutions are described in the following section).

In the last step, the reduction potential, costs and investment needs are computed per company, according to the size of their impacts per region per solution group, considering both direct activities and the activities in their supply chain.

7.3 Solutions for greenhouse gas emissions

Climate-change related solutions are taken from the Drawdown project[26], which published the best-selling environmental book of 2017 (Hawken, 2017) covering 100 science-based solutions for tackling climate change. This book considers global reduction potential of these solutions, how they can help and how much it would cost (net savings and net costs) to reverse climate change

25. To avoid double counting, two categories of solutions are effectively modeled: solutions for climate change and for water scarcity. Land use and transformation, as well as biodiversity losses are thus covered implicitly. IPBES drivers such as pollution, natural resources use and exploitation, and invasive species are thus not included: https://ipbes.net/models-drivers-biodiversity-ecosystem-change .

26. www.drawdown.org .

in the coming decades (achieving carbon net zero, i.e. human emissions-equal sequestration) and drawdown, i.e. a decrease in the atmospheric concentration GHGs year over year. In this report, the evaluation of the gap (i.e. the reduction needs) is based on a simple approach: all GHG emissions have to be stopped. The size of the gap is thus proportional to current emissions.

The main solutions from Drawdown are modeled in various ways according to available data and models. They are all modeled by considering country and sector specificities. Costs originate from various sources, all recognized for their credibility (except for HFC for which simple estimates have been made) when the Drawdown costs could not be considered due to them being too generic (one global price only).

The six main GHG emissions (CO_2, CH_4, N_2O, SF_6, HFC and PCF) were considered in analyzing the solutions. Their impact was evaluated for the following five solution 'groups':

- Sustainable agriculture: non-combustion emissions of N_2O and CH_4 from agriculture
- Renewable electricity: combustion of fossil fuels for electricity generation, including combined heat and power (CHP) generation
- Sustainable heating: combustion of CO_2 and upstream non-combustion emissions of CH_4 from heating fuels
- Sustainable transportation: combustion of CO_2 and upstream non-combustion emissions of CH_4 from transportation fuels
- Sustainable refrigeration/AC: HFC emissions

In addition, emissions covering industrial emissions of CO_2 (for example, cement or steel production) and other sources of emissions, such as N_2O from combustion are also considered but from another angle, i.e., in terms of offsetting or investments in carbon sinks.

Sustainable agriculture

The solutions evaluated to reduce current GHG emissions from agriculture, cover crop land management.

Renewable electricity

Solutions were evaluated to substitute fossil fuels (coal, gas, petroleum and other oil derivatives, etc.) and nuclear energy in the production of electricity to match the 2050 target of the REmap case from IRENA (2019). Solution costs and avoided costs were then computed with prices

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based on the LCOE (Levelized Cost of Energy) per energy type as provided in OECD et al., 2015. Six solutions applied over 22 countries were assessed and extrapolated to the rest of the world.

Sustainable transportation

Introduction of renewable electricity in place of fossil fuels was also considered to reduce the CO_2 emissions from combustion and upstream CH_4 non-combustion emissions due to transportation (see above). In the model, emissions induced by transportation are defined as the emissions from the following fuels which are not burned by the electricity production sector: aviation gasoline, gasoline type jet fuel, kerosene, kerosene type jet fuel, gas/diesel oil, liquefied petroleum gases (LPG), motor gasoline. Emissions were computed by multiplying the quantities of each type of energy source with emissions factors from several public sources.

Sustainable heating

Like in the case of the above two solution groups, the use of renewable electricity in place of fossil fuels to reduce the CO_2 emissions from combustion and upstream CH4 non-combustion induced by heating was considered. In the model, emissions induced by heating are defined as the emissions from the following fuels which are not burned by the electricity production sector or for industrial purposes (for example, cement or steel production) – anthracite, BKB/ peat briquettes, charcoal, coke oven coke, coke oven gas, natural gas and services related to natural gas extraction, excluding surveying, gas works gas, gas coke, natural gas liquids, crude petroleum and services related to crude oil extraction, excluding surveying, heavy fuel oil, non-specified petroleum products, other hydrocarbons, peat. Emissions were computed by multiplying the quantities of each type of energy source with emissions factors from several public sources.

Sustainable refrigeration/AC

Solutions are evaluated to replace all HFC by gases with lower global warming potential.

Other GHG emissions

Other GHG emissions (i.e. emissions of SF_6, PFC, etc.) for which solutions are not evaluated are considered in terms of offsetting (CHF 6 per tonne of CO_2-equivalent) or investment in carbon sinks (CHF 30 per tonne of CO_2-equivalent)

Reducing deforestation

To stop deforestation, several solutions are possible for sustainable forest management/ reforestation. The area to be protected/reforested is estimated per crop in each country as the average area deforested yearly over the period 2007 to 2011 (Blonk consultants, 2014). The

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CO_2 emissions were taken from the same source and account for the different types of soils. A weighted-average deforestation per ha was then computed for the agricultural sectors of the economy-energy-environment model using production quantities as weighting factor. Solution costs were based on a global average price based on expert judgment (CHF 500 per ha). Avoided costs were considered to be nil.

7.4 Solutions for water scarcity

Agricultural and industrial water demand management as well as water supply solutions

Sustainable water management is required to tackle the current/forthcoming water crises. Strong et al. (2020) estimate the global annual cost of delivering sustainable water management as USD (or CHF) 1.04 trillion annually (from 2015 to 2030). This cost of action considers the six challenges of the Sustainable Development Goal 6 from the United Nations.

We consider here the solutions for closing the gap between current conditions and desired conditions for the largest challenge – water scarcity. The three main components of the water gap are considered – agriculture (73% of the gap at global scale), industry (11% of the gap) and supply (8% of the gap).

Following Strong et al. (2019), the projected annual country water gap was computed per country for 2030 by aggregating evaluations of monthly water stresses (water withdrawal for activities over available renewable water supply, deducting from supply the requirements of the environment at catchment level). The size of the gap was estimated separately for the agriculture, industry and water supply sectors using best-in-class countries per sector (top 20%). The current gap was evaluated by assuming a constant gap/withdrawal rate over time, i.e., by multiplying current withdrawal by the 2030 gap/withdrawal rate.

To close the annual gap, 76 solutions covering demand management in agriculture and in industry as well as water supply solutions (applied when demand management solutions are not sufficient to close the gap in a sector) were considered based on sector-specific cost curves which prioritized the solutions from least cost to greatest cost. Solution costs are based on prices available for four countries as provided by The 2030 Water Resources Group (2009) and extrapolated for missing countries using GDP in PPP. Avoided costs were computed as the reduction in water use multiplied by the implicit water costs as taken from the global economic-energy-environmental model.

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8. Appendix B: SMI and company factsheets

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A detailed factsheet is presented for the SMI and for each of the considered company.

https://costofsolutions.ch/ .

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